

Natural Conditions  
Assessment for low DO,  
Mount Landing Creek  
Essex County, Virginia

**Submitted by**

**Virginia Department of Environmental Quality**

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## Executive Summary

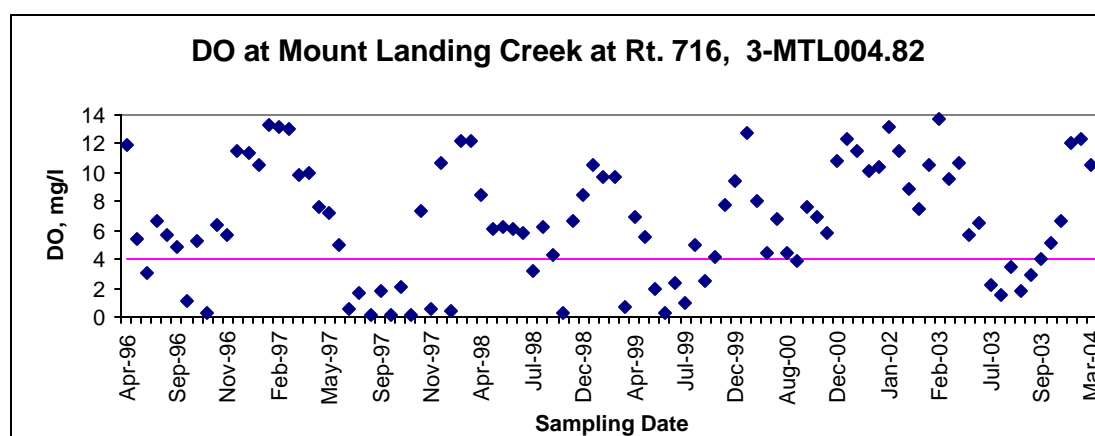
This report presents the assessment of whether low dissolved oxygen (DO) in the Mount Landing Creek watershed is due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Mount Landing Creek is located in Essex County in the Rappahannock River Basin (USGS Hydrologic Unit Code 02080104). The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal portion of Mount Landing Creek is VAP-E22R. There are 35.2 total stream miles in the Mount Landing watershed (National Hydrography Dataset (NHD), of which 4.4 miles are tidal, encompassing 0.16 square miles.

The drainage area of the Mount Landing Creek watershed is approximately 64.3 square miles. The average annual rainfall as recorded in Ashland, VA, within 13 miles of the study area is 42.2 inches. The approximately 41,200 acre watershed is predominately forested (52.3 percent). Agriculture encompasses 22.0 percent of the watershed, with 5.4 percent cropland and 16.5 percent pasture/hayland. Residential and high use industrial areas compose approximately 19.7 percent of the land base. Transitional use composes 1.5 percent of the watershed. The remaining 4.7 percent of the watershed is comprised of wetlands and open water.

There are three impaired segments totaling 8.53 rivermiles. The three impaired segments are 1.19 miles in mainstem Mount Landing Creek, from the first tributary above the Rt. 716 bridge at rivermile 5.63, downstream to the head of tide at approximately rivermile 4.44, impaired for low DO, low pH, and fecal coliform bacteria; 4.91 miles of mainstem Mount Landing Creek from the confluence of Bull Neck Creek downstream to the first tributary at rivermile 5.63 above the Rt. 716 bridge, impaired for low pH; and 2.43 miles of a UT to Mount Landing Creek from its headwaters to its mouth, impaired for low pH. A bacterial TMDL and an assessment of low pH due to natural conditions will be performed on the Mount Landing Creek watershed in separate documents.

Mount Landing Creek was listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report (VADEQ 1998) due to violations of the State's water quality standard for dissolved oxygen. A total of 97 DO data points, with 27 water quality standard violations (27.8%), have been taken by DEQ at station 3-MTL004.82 (see Figure E1) from April 11, 1996 through May 18, 2004

**Figure E1. Time series of DO concentrations (station 3-MTL004.82), April 1996 to May 2004.**



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected

to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).”

As indicated above, Mount Landing Creek must support all designated uses and meet all applicable criteria. The Mount Landing Creek does not appear to support aquatic life use because of DO water quality standard violations.

VADEQ proposes a methodology for determining whether low DO originates from natural or anthropogenic sources, adapted from “Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia.” (MapTech 2003)

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions in a free-flowing stream that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of wetlands, and often low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process.

These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure for low DO, all DO data should be screened for flows less than the 7Q10. DO data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

- Step 1. Determine slope and appearance (presence of wetlands).
- Step 2. Determine nutrient levels and compare with USGS background concentrations.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

There were no low DO violations while flows were equal to or less than 7Q10.

Mount Landing Creek exhibits low slope (0.19%) with significant wetlands. These contribute large inputs of decaying vegetation, which when decomposed by bacteria in the water lower DO as they decay. These are not considered anthropogenic impacts.

Mount Landing Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which not indicative of human impact.

Mount Landing Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high.

There are no permitted dischargers in the Mount Landing Creek watershed. Residential / Commercial land use (0.2%) probably has no DO effect on the northern tributaries or tidal areas.

Based on the above findings, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Mount Landing from Rivermile 10.40 at Rt. 629, downstream to the head of tide at rivermile 4.44. The size of the Swampwater segment may increase pending the low pH assessment for natural conditions. If there is a 305(b)/303(d)

305(b)/303(d) assessment prior to the reclassification, Mount Landing Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Mount Landing Creek low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

## 1. Introduction

Mount Landing Creek and an unnamed tributary (UT) to Mount Landing Creek were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998 & 2004) due to violations of the State's water quality standard for dissolved oxygen (DO, 1998) and pH (1998 and 2004) and fecal coliform bacteria (2004). This report evaluates the DO impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The pH and fecal coliform bacteria impairments will be addressed separately from this document.

A glossary of terms used throughout this report is presented as Appendix A.

## 2. Physical Setting

### 2.1 Listed Water Bodies

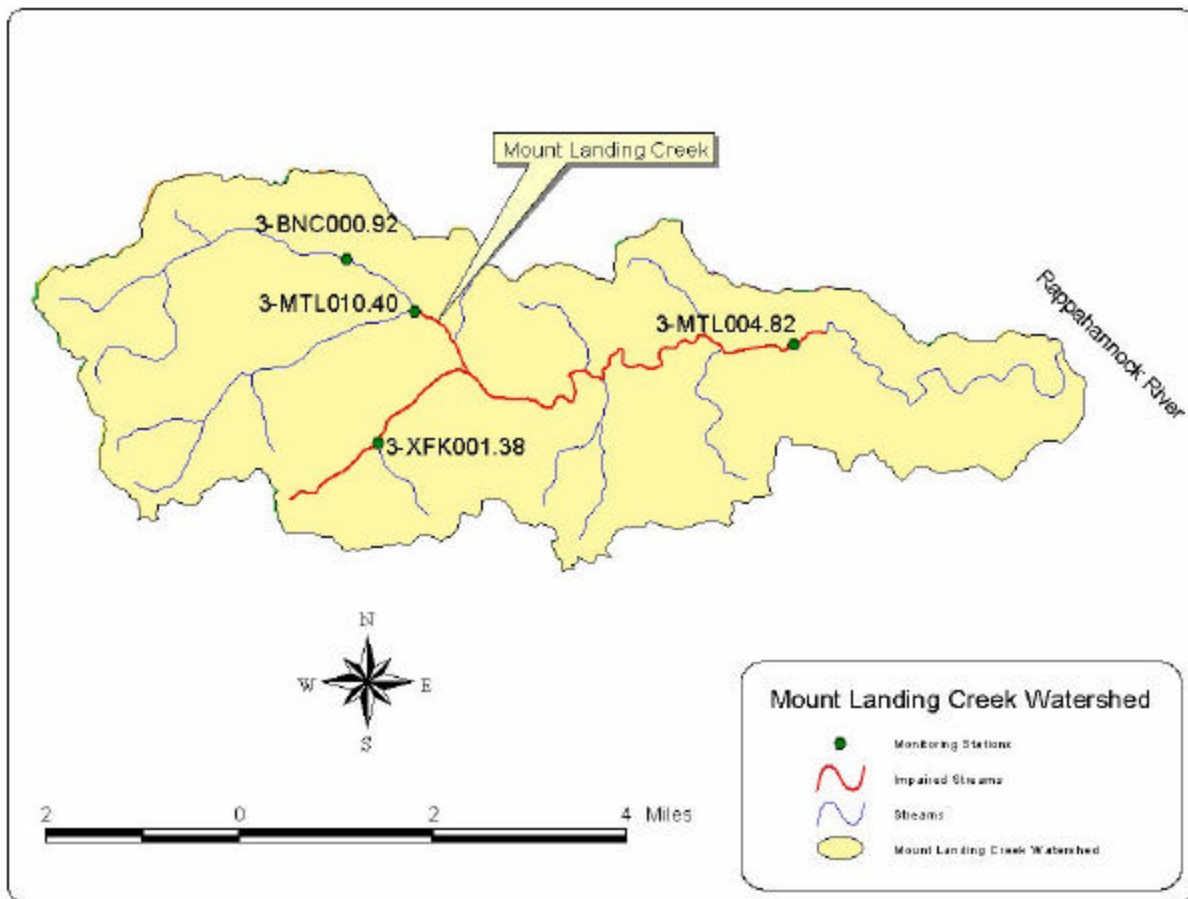
Mount Landing Creek is located in Essex County in the Rappahannock River Basin (USGS Hydrologic Unit Code 02080104). The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal portion of Mount Landing Creek is VAP-E22R. There are 35.2 total stream miles in the Mount Landing watershed (National Hydrography Dataset (NHD), of which 4.4 miles are tidal, encompassing 0.16 square miles. There are three impaired segments totaling 8.53 rivermiles. The four impaired segments are 1.19 miles in mainstem Mount Landing Creek, from the first tributary above the Rt. 716 bridge at rivermile 5.63, downstream to the head of tide at approximately rivermile 4.44, impaired for low DO, low pH, and fecal coliform bacteria; 4.91 miles of mainstem Mount Landing Creek from the confluence of Bull Neck Creek downstream to the first tributary at rivermile 5.63 above the Rt. 716 bridge, impaired for low pH; and 2.43 miles of a UT to Mount Landing Creek from its headwaters to its mouth, impaired for low pH. These segments are described in Table 1 and Figure 1.

**Table 1. Impaired segment descriptions (Mount Landing Creek and UT to Mount Landing Creek)**

<b>Segment (segment ID)</b>	<b>Impairments (sources of impairment)</b>	<b>Upstream Limit Description</b>	<b>Downstream Limit Description</b>	<b>Miles Affected</b>
<b>Mount Landing Creek</b> (Seg ID# VAP-E23R- 02 & 06)	pH Dissolved Oxygen Fecal Coliform bacteria	First Tributary confluence to Mount Landing Creek at RM 5.63 above Route 716	Head of tide at RM 4.44	1.19
<b>Mount Landing Creek</b> (Seg ID# VAP-E23R- 07)	pH	Confluence of Bull Neck Creek with Mount Landing Creek at RM 10.40	First Tributary confluence to Mount Landing Creek at RM 5.63 above Route 716	4.91
<b>Unnamed Tributary to Mount Landing Creek</b> (Seg ID# VAP-E23R- 05)	pH	Headwaters of UT	Confluence with Mount Landing Creek	2.43

**Figure 1. Map of the Mount Landing Creek study area**





## 2.2. Watershed

### 2.2.1. General Description

Mount Landing Creek, located within Essex County, is a minor tributary to the Rappahannock River. It is about 15 miles long and flows southeastward from its headwater near Carneal Corners to its confluence with the Rappahannock River. The watershed itself is approximately 11 miles long and 3 miles wide, having an area of 26.1 square miles. The major tributaries to Mount Landing Creek are Bull Neck Creek and Croxton Stream entering from the west, and three unnamed tributaries entering from the south. There is no continuous flow gaging station on Mount Landing Creek, however there is a gage on Piscataway Creek near Tappahannock, VA, 01669000, located six miles south of Mount Landing Creek, with a drainage area of 28.0 mi<sup>2</sup>.

### 2.2.2. Geology, Climate, Land Use

#### **Geology and Soils**

Mount Landing Creek is in the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic

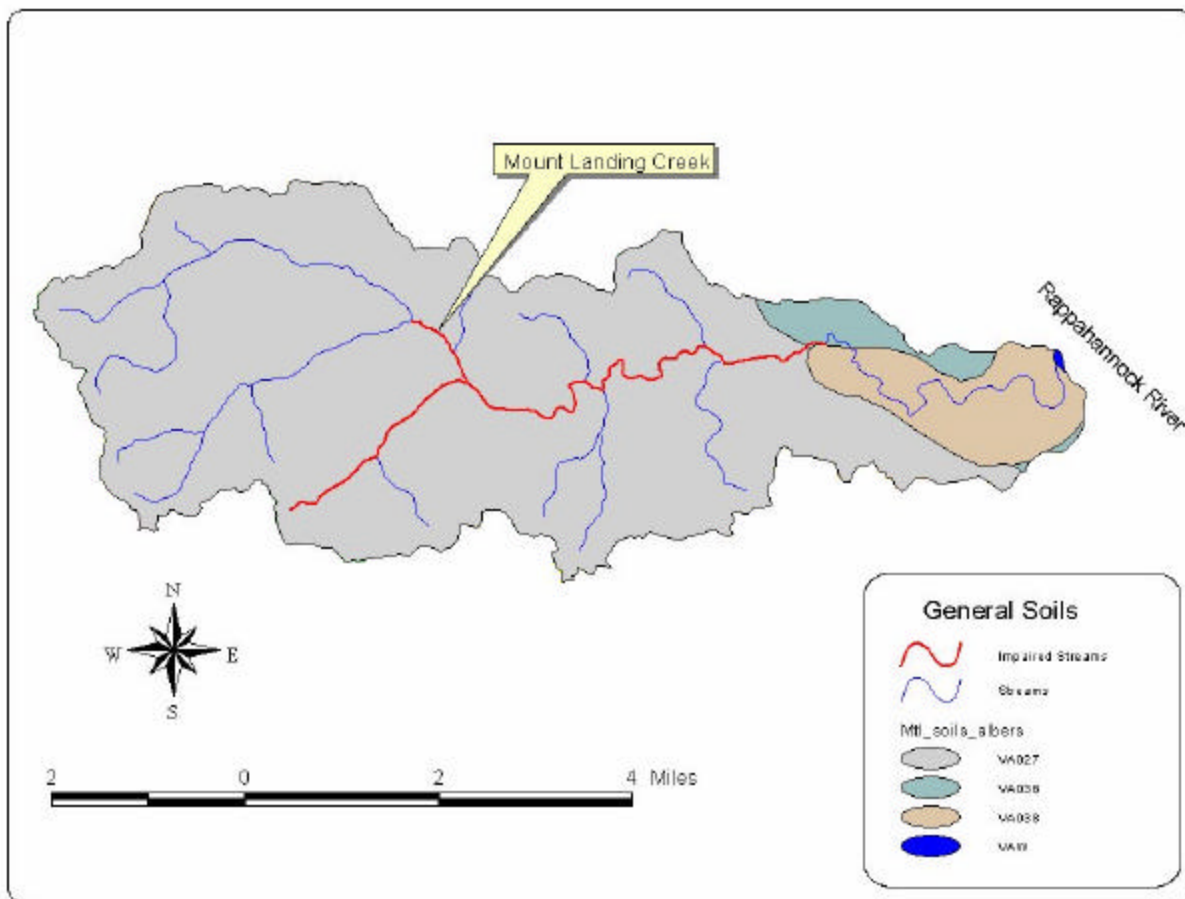
rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (<http://www.geology.state.va.us/DOCS/Geol/coast.html>).

Soils for the Mount Landing Creek watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (<http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi>). Figure 2 shows the location of these general soil types in the watershed.

Soils of the Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027) series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow permeability. They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

Soils of the Tetotum-Nansemond-State-Emporia-Dragston-Nimmo-Bladen Series (VA036) are very deep and range from well drained to poorly drained. Permeability ranges from moderately rapid and/or rapid to moderately slow or slow. This soil series was formed in sandy or loamy fluvial and marine sediments on Coastal Plain uplands and stream terraces.

The Pamunkey-Nansemond-Bibb-Kinston-Nawney-Bohicket Series (VA038) are very deep, poorly to well drained soils, and range from well to moderately well to slow permeability. These soils are located on low stream or marine terraces and in the flood plains in the Piedmont and the Coastal Plain Physiographic Provinces. These soil series are formed in fine to coarse loamy marine and fluvial sediments and sandy alluvium.

**Figure 2. Soil Characteristics of the Mount Landing Creek Watershed****Climate**

The climate summary for Mount Landing Creek comes from a weather station located in Warsaw, VA, with a period of record from 1/1/1951 to 3/31/2004. The average annual maximum and minimum temperature (°F) at the weather station is 68.7 and 46.9 and the annual rainfall (inches) is 43.04 (Table 2) (Southeast Regional Climate Center, [http://www.sercc.com/climateinfo/historical/historical\\_va.html](http://www.sercc.com/climateinfo/historical/historical_va.html)).

**Table 2. Climate summary for Warsaw, Virginia (448894)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
<b>Average Max. Temperature (F)</b>	46.4	50.0	58.4	69.5	77.5	85.1	88.8	87.1	81.1	70.7	60.3	49.8	68.7
<b>Average Min. Temperature (F)</b>	27.4	29.5	36.0	44.9	54.0	62.4	67.0	65.6	58.7	47.4	39.0	30.9	46.9
<b>Average Total Precipitation (in.)</b>	3.14	2.81	3.83	2.98	4.12	3.56	4.49	4.38	4.13	3.34	3.16	3.11	43.04

### **Land Use**

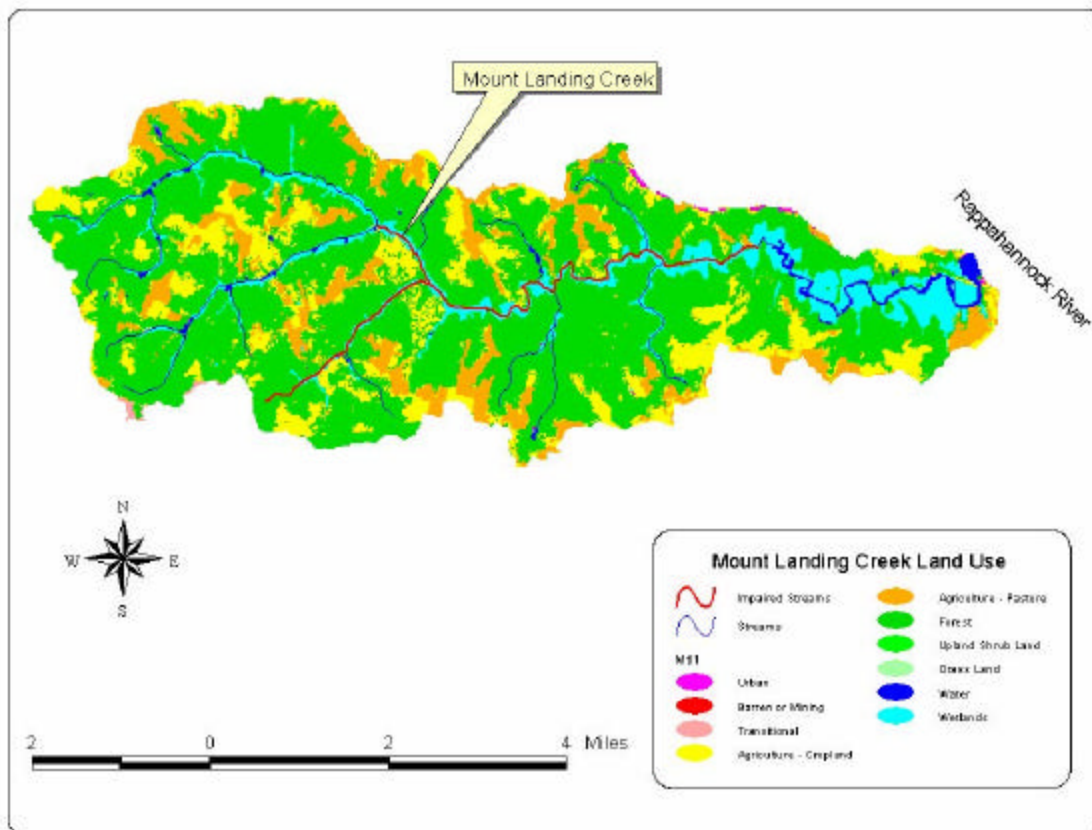
The Mount Landing Creek watershed extends approximately 11 miles upstream from the stream's confluence with the Rappahannock River and is approximately 3 miles wide. The approximately 16,700 acre watershed is predominately forested (63.8 percent). Agriculture encompasses 26.4 percent of the watershed, with 15.4 percent cropland and 11.0 percent pasture/hayland. Residential and high use industrial areas compose approximately 0.2 percent of the land base. The remaining 4.7 percent of the watershed is comprised of wetlands.

A table and map of the distribution of land use in the watershed (Table 3 and Figure 3) show that the small percentage of urban land is found along the northern boundary of the watershed. Forest land is throughout the watershed. Agriculture is scattered in the higher elevation areas throughout the watershed.

**Table 3. Land Use in the Mount Landing Creek watershed.**

<u>Landuse</u>	<u>Acres</u>	<u>Sq Miles</u>	<u>Percent of Total</u>
Open Water	192.59	0.30	1.15
Low Intensity Residential	3.78	0.01	0.02
High Intensity Residential	0.00	0.00	0.00
High Intensity Commercial/Industrial/Transportation	36.03	0.06	0.22
Bare Rock/Sand/Clay	0.00	0.00	0.00
Quarries/Strip Mines/Gravel Pits	0.00	0.00	0.00
Transitional	24.24	0.04	0.15
Deciduous Forest	6863.99	10.71	41.09
Evergreen Forest	631.82	0.99	3.78
Mixed Forest	3152.89	4.92	18.87
Pasture/Hay	1832.98	2.86	10.97
Row Crops	2564.66	4.00	15.35
Other Grasses (Urban/recreational; e.g. parks)	0.00	0.00	0.00
Woody Wetlands	843.54	1.32	5.05
Emergent Herbaceous Wetlands	<u>558.43</u>	<u>0.87</u>	<u>3.34</u>
Total:	16704.97	26.06	100.00

**Figure 3. Land Use in the Mount Landing Creek Watershed**



### 3. Description of Water Quality Problem/Impairment

Mount Landing Creek and an unnamed tributary (UT) to Mount landing Creek were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998 & 2004) due to violations of the State's water quality standard for dissolved oxygen (DO, 1998) and pH (1998 and 2004) and fecal coliform bacteria (2004). A total of 97 DO data points, collected on 77 distinct sample dates, with 27 water quality standard violations (27.8%), sampled on 20 distinct dates, have been taken by DEQ at station 3-MTL004.82 (see Figure 1) from April 11, 1996 through May 18, 2004 (Table 4). Two sample depth DO readings were collected on 20 sample dates, with DO values at both sample depths below the water quality standard for DO on 6 distinct dates.

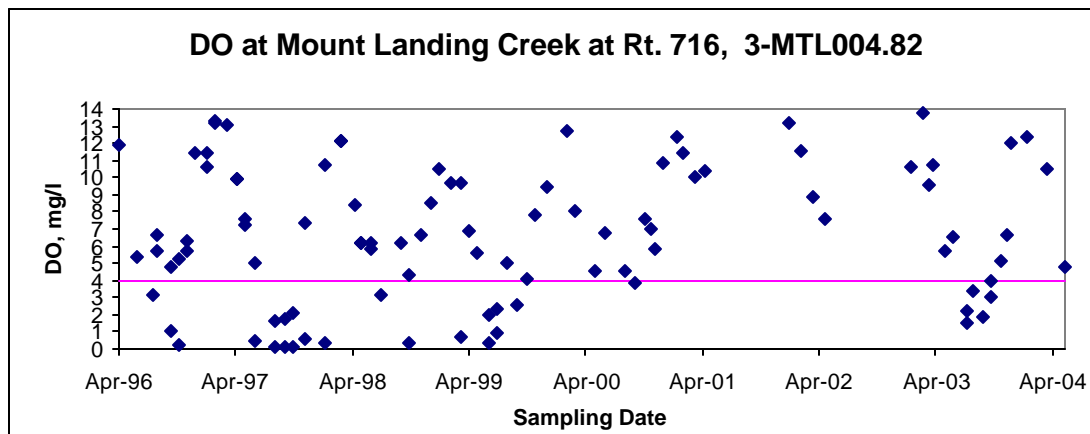
**Table 4. DO data collected by DEQ on Mount Landing Creek at Rt. 716**

Station	Date of First Sample	Date of Last Sample	Number of Samples	mg/l			Number of Violations
				Average	Minimum	Maximum	
3-MTL004.82	04/11/1996	05/14/2004	97	6.59	0.08	13.75	27

A time series graph of all data collected at station 3-MTL004.82 shows the DO concentrations ranging from 0.08 mg/l to 13.75 mg/l (Figure 4). The horizontal line at the DO = 4.0 mg/l mark represents the

minimum water quality standard. The data points below the DO = 4.0 mg/l line illustrate violations of the water quality standard.

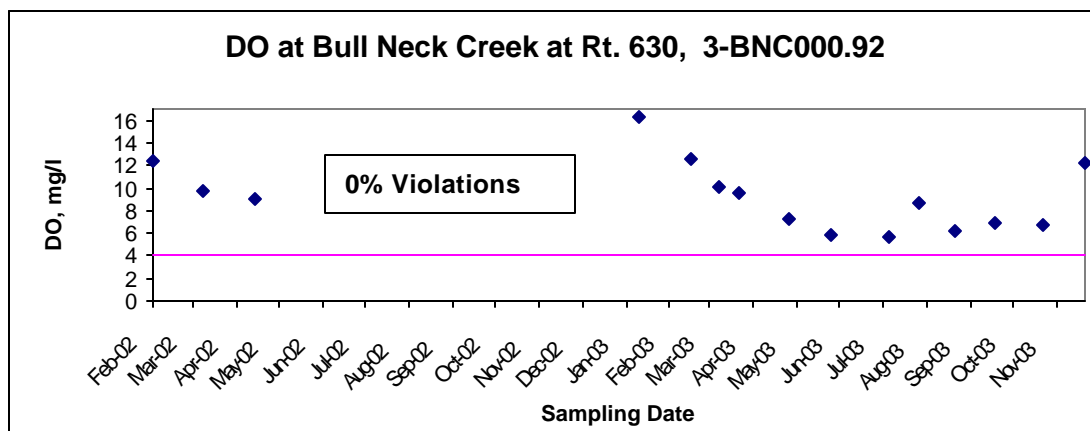
**Figure 4. Time series of DO Concentrations at Mount Landing Creek at Rt. 716, 3-MTL004.82.**



### 3.1 Associated Mainstem and Tributary site DO

DEQ added several associated mainstem and tributary monitoring stations during data collection for the low DO assessment of natural conditions or development of a TMDL. Associated station DO data are presented in Figures 5 - 7 below.

**Figure 5. Time series of DO Concentrations at Bull Neck Creek at Rt. 630, 3-BNC000.92.**



**Figure 6. Time Series of DO Concentrations at Mount Landing Creek at Rt. 629, 3-MTL010.40.**

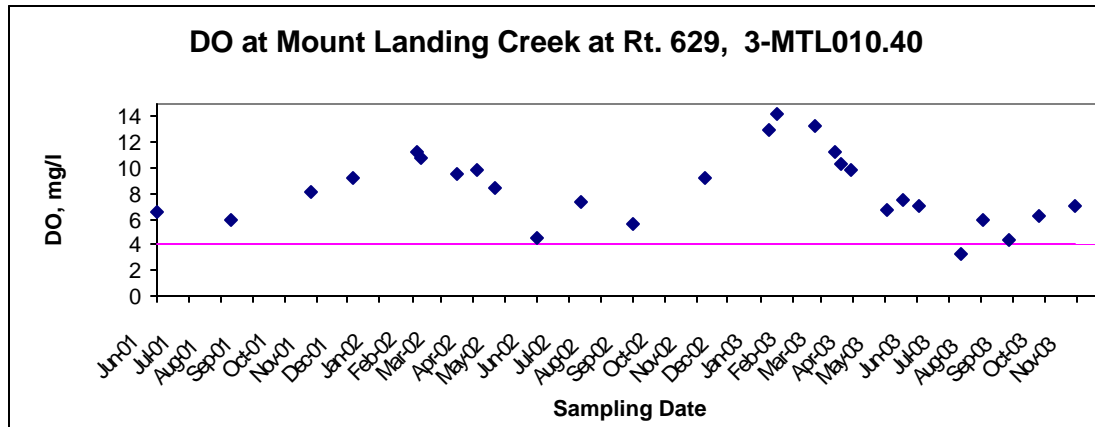
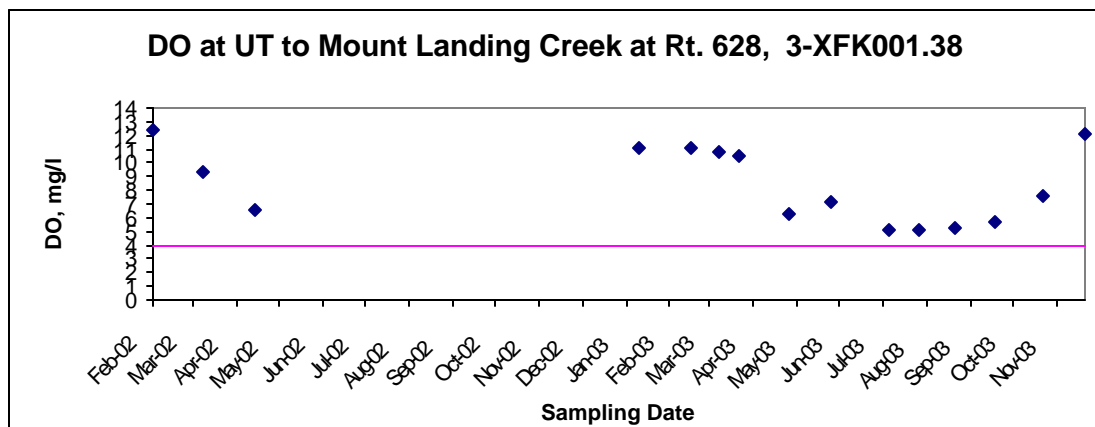


Figure 7. Time Series of DO Concentrations at UT to Mount Landing Creek at Rt. 628, 3-XFK001.38.



## 4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term “water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.).”

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

### 4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), “all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).”

As stated above, Mount Landing Creek must support all designated uses and meet all applicable criteria.

## 4.2. Applicable Water Quality Criteria

The applicable water quality criteria for pH in the Mount Landing Creek watershed is an instantaneous minimum DO of 4.0 mg/l.

**Table 5. Applicable water quality standards**

Parameter	Minimum, mg/l	Maximum, mg/l
DO	4.0	na

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

## 5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

- Step 1. Determine slope and appearance.
- Step 2. Determine nutrient levels.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts.

**The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.**



# Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality  
October 2004

## I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen-restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water

Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

## **II. NATURAL CONDITION ASSESSMENT**

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

### **Step 1. Determine appearance and flow/slope.**

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

### **Step 2. Determine nutrient levels.**

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

#### Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

#### Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Skinquarter Creeks.

#### 7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, Impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

### III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND  
If wetlands are present along stream reach AND  
If no point sources or only point sources with minimal impact on DO and pH AND  
If nutrients are < typical background  
❖ average (= assessment period mean) nitrate less than 0.6 mg/L  
❖ average total nitrogen (TN) less than 1.0 mg/L, and  
❖ average total phosphorus (TP) are less than 0.1 mg/L AND  
For DO: If seasonal fluctuation is normal AND  
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,  
  
THEN determine as impaired due to natural condition  
→ assess as category 4C in next assessment  
→ initiate WQS reclassification to Class VII Swamp Water  
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

#### 5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. There is no long-term flow gaging station in the Mount Landing Creek basin

The 7Q10 flow for Mount Landing Creek DO stations may be estimated by a drainage area ratio from the Piscataway Creek near Tappahannock, VA gaging station located 6 miles to the south. The drainage area of the Piscataway Creek gage = 28.0 mi<sup>2</sup>, and of the Mount Landing Creek watershed = 26.1 mi<sup>2</sup>. The 7Q10 of Piscataway Creek for the period 1952 – 2001 is 0.03 cfs. Using the drainage area ratio, the 7Q10 of Mount Landing Creek is also 0.03 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 \*\*\*). Therefore in streams where the 7Q10 > 0 cfs, DO less than 4 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

Performing the preliminary 7Q10 screening on the Mount Landing Creek DO datasets, the results are in Table 6 below. There were no low DO violations while flows were equal to or less than 7Q10.

**Table 6. Mount Landing Creek 7Q10 Flow Vs. DO Violation Screening.**

Piscataway Creek gage 7Q10= 0.03 cfs, 1952 - 2001, at 28.0 mi<sup>2</sup> drainage area  
 MTL = 26.1 mi<sup>2</sup> drainage area, 7Q10 estimated at 0.03 cfs, Q < 7Q10 Aug 9-13, 1999; Jul 22,23, Aug 8 - Sept 1, 2002.  
 26.8% Total DO violations  
 26.8% 7Q10 corrected DO violations. There were no low DO violations while flows were equal to or less than 7Q10.

## ***5.2 Low slope, Swamps, Wetlands or Large Forested Areas***

There were no discharge measurements made at the Rt. 716 bridge, the original 303(d) listing station. The hydrologic slope from the 60 ft. topographic contour at rivermile 10.41 just above Rt. 629 downstream to the head of tide at the zero elevation contour at rivermile 4.44 located 0.38 mi below Rt. 716 is estimated at 0.19%, which is considered very low slope. The low slope contributes no human impact.

Visual inspection at bridges on Rt. 716 (Figure 8) and Rt.629 (Figure 9) revealed very swampy conditions. A large wetland area exists for about 4 miles above Rt. 716 on the land use map (see Figure 3), and it is especially wide immediately above Rt. 716. Wetlands are also noted from rivermile 10.40 at Rt. 629 downstream to the confluence with the Rappahannock River. Wetlands promote input of decaying vegetation, which causes low DO from bacterial decomposition. The wetlands impacts are not indicative of human impact.

**Figure 8. Mount Landing Creek upstream of Rt. 716.**





**Figure 9. Mount Landing Creek downstream of Rt. 629.**



### 5.3 Instream Nutrients

The VADEQ collected nutrient data from station 3-MTL004.82 from June 1996 to August 2004. The average nutrient concentrations (Table 7) are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; total nitrogen (TKN + NO<sub>3</sub> + NO<sub>2</sub>) < 1.0 mg/l; and total phosphorus < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

**Table 7. Instream Nutrients of Mount Landing Creek at Rt. 716, 3-MTL004.82.**

Parameter	Average Conc.	Number
<b>Total Phosphorus</b>	<b>0.090 mg/l</b>	(n=52)
Orthophosphorus	0.058 mg/l	(n=44)
Total Kjeldahl Nitrogen	0.697 mg/l	(n=46)
Ammonia as N	0.076 mg/l	(n=52)
Nitrite + Nitrate as N	0.102 mg/l	(n=53)
<b>Total Nitrogen</b>	<b>0.764 mg/l</b>	(n=46)
<b>Nitrate as N</b>	<b>0.041 mg/l</b>	(n=41)

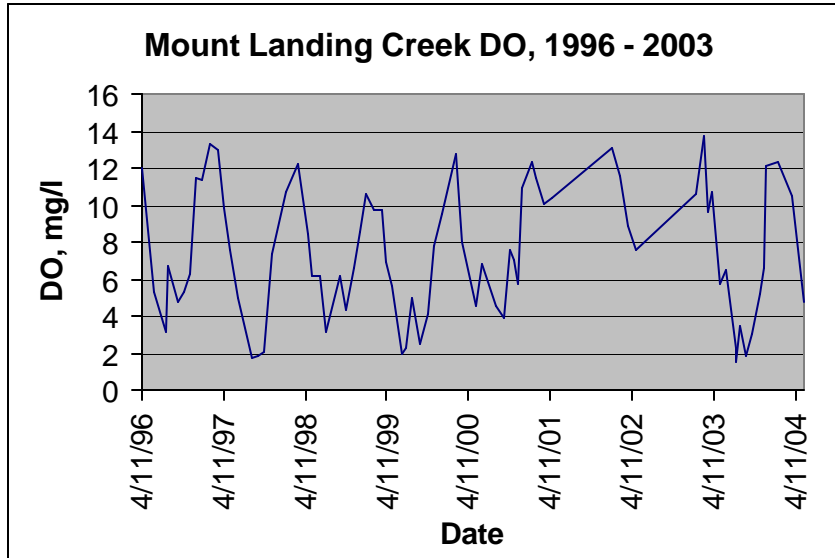
These levels of nitrate, total nitrogen and total phosphorus (bolded in black) are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO<sub>3</sub> + NO<sub>2</sub>) < 1.0 mg/l; and TP < 0.1 mg/l.

### 5.4 Natural Seasonal DO Fluctuation

Mount Landing Creek exhibits natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 10.

**Figure 10. Seasonal Variation in DO at Mount Landing Creek at Rt. 716, 1996 – 2003.**





## 5.5 Impact from Point Source Dischargers and Land Use

There are no permitted point source discharges in the Mount Landing Creek watershed.

Residential and high use industrial areas (39.8 acres) compose approximately 0.2 percent of the land base, along the northern boundary of the watershed. The watershed is predominately forested (63.8 percent), with 4.7 percent wetlands. This land use was considered not indicative of human impact.

## 6.0 CONCLUSION

***The following decision process is proposed for determining whether low pH values are due to natural conditions:***

If slope is low (<0.50) AND

If wetlands are present along stream reach AND

If no point sources or point sources with minimal impact on pH AND

If nutrients are < typical background

❖ average (= assessment period mean) nitrate less than 0.6 mg/L

❖ average total nitrogen (TN) less than 1.0 mg/L, and

❖ average total phosphorus (TP) are less than 0.1 mg/L AND

If nearby streams without wetlands meet pH criteria,

THEN determine as impaired due to natural condition

→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water

→ get credit under consent decree

Mount Landing Creek exhibits low slope (0.19%) with significant wetlands. These contribute large inputs of decaying vegetation, which when decomposed by bacteria in the water lower DO as they decay. These are not considered anthropogenic impacts.

Mount Landing Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which not indicative of human impact.

There are no permitted dischargers in the Mount Landing Creek watershed. Residential / Commercial land use (0.2%) probably has no DO effect on the northern tributaries or tidal areas.

Based on the above findings, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Mount Landing from Rivermile 10.40 at Rt. 629, downstream to the head of tide at rivermile 4.44. The size of the Swampwater segment may increase pending the low pH assessment for natural conditions. If there is a 305(b)/303(d) assessment prior to the reclassification, Mount Landing Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

## **7.0. Public Participation**

DEQ performed the assessment of the Mount Landing Creek low DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

## **8. References**

Maptech, Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia. 2003.

SRCC (Southeast Regional Climate Center)

[http://www.dnr.state.sc.us/climate/sercc/products/historical/historical\\_va.html](http://www.dnr.state.sc.us/climate/sercc/products/historical/historical_va.html) (Accessed 12/18/02)

USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 1998. Virginia. 1998.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 2002. Virginia. 2002.

## **Appendix A**

### **Glossary**

## GLOSSARY

**Note:** All entries in italics are taken from USEPA (1998). All non-italicized entries are taken from MapTech (2002).

**303(d).** A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

**7Q10.** The lowest streamflow for seven consecutive days that occurs on average once every ten years.

***Ambient water quality.*** Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.

***Anthropogenic.*** Pertains to the [environmental] influence of human activities.

***Background levels.*** Levels representing the chemical, physical, and Bacterial conditions that would result from natural geomorphological processes such as weathering or dissolution.

***Best management practices (BMPs).*** Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

***Clean Water Act (CWA).*** The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.

***Concentration.*** Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).

***Confluence.*** The point at which a river and its tributary flow together.

***Contamination.*** The act of polluting or making impure; any indication of chemical, sediment, or Bacterial impurities.

***Designated uses.*** Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.

***Dilution.*** The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.

**Direct runoff.** Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.

**Discharge.** Flow of surface water in a stream or canal, or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.

**Discharge permits (under VPDES).** A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.

**Domestic wastewater.** Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.

**Drainage basin.** A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.

**Effluent.** Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.

**Effluent limitation.** Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.

**Existing use.** Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).

**GIS.** Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

**Hydrologic cycle.** The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.

**Hydrology.** The study of the distribution, properties, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

**In situ.** In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.

**Margin of safety (MOS).** A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the

*receiving waterbody (CWA section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).*

**Mean.** The sum of the values in a data set divided by the number of values in the data set.

**MGD.** Million gallons per day. A unit of water flow, whether discharge or withdraw.

**Monitoring.** *Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.*

**Narrative criteria.** *Nonquantitative guidelines that describe the desired water quality goals.*

**National Pollutant Discharge Elimination System (NPDES).** *The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.*

**Natural waters.** *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

**Non-point source.** *Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.*

**Numeric targets.** *A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.*

**Organic matter.** *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

**Peak runoff.** *The highest value of the stage or discharge attained by a flood or storm event; also referred to as flood peak or peak discharge.*

**Permit.** *An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

**Point source.** Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.

**Pollutant.** Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, Bacterial materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).

**Pollution.** Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, Bacterial, chemical, and radiological integrity of water.

**Public comment period.** The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).

**Raw sewage.** Untreated municipal sewage.

**Receiving waters.** Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.

**Restoration.** Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.

**Riparian areas.** Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.

**Riparian zone.** The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.

**Runoff.** That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

**Slope.** The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).

**Stakeholder.** Any person with a vested interest in assessment of natural condition or TMDL development.

**Standard.** In reference to water quality (e.g. pH 6 – 9 SU limit).

**Storm runoff.** *Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

**Streamflow.** *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

**Stream restoration.** *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

**Surface area.** *The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.*

**Surface runoff.** *Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.*

**Surface water.** *All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.*

**Topography.** *The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.*

**Total Maximum Daily Load (TMDL).** *The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.*

**Tributary.** *A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

**Variance.** *A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.*

**DCR.** Department of Conservation and Recreation.

**DEQ.** Virginia Department of Environmental Quality.

**VDH.** Virginia Department of Health.



**Wastewater.** Usually refers to effluent from a sewage treatment plant. See also **Domestic wastewater**.

**Wastewater treatment.** Chemical, Bacterial, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.

**Water quality.** The Bacterial, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.

**Water quality criteria.** Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

**Water quality standard.** Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

**Watershed.** A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.